Interactive Learning with a Web-based Digital Library System

by John A. N. Lee[1]

Abstract

With support from the National Science Foundation, the Faculty of the Department of Computer Science at Virginia Tech has constructed a number of on-line courses in support of the undergraduate program. Almost 75% of all courses in the department have a Web presence, and a growing number regard the Web as their primary resource. Starting from the concept of a passive Digital Library, the course offerings are now moving towards a much more interactive mode of learning, utilizing on-line testing systems and collaborative learning, and incorporating elements of active learning. Starting from "local" Web-Based learning, the site is preparing for the advent of "distance education". The presentation will be a progress report on one aspect of this project and the plans for future development and dissemination.

Introduction

Key concepts of the 1994-1997 NSF-funded Education Infrastructure (EI) project[2] were to improve CS education by increasing interactivity and use of a digital library. The main objectives/accomplishments were to:

1. Expand the content and software (especially interfaces initially developed with NSF support of our »Envision" digital library project, »A User-Centered Database from the Computer Science Literature"
2. Develop/apply algorithm visualization tools
3. Incorporate use of specialized digital library systems into related courses,
4. Add new courses related to human-computer interaction, multimedia, and a freshman level introduction to Networked Information,
5. Significantly change courses like »Computer Professionalism", to make use of interactivity (e.g., asynchronous on-line debates) and digital library support (e.g., adding to a large History collection), and
6. Apply the key concepts to improve other courses.

The resulting changes have far exceeded our expectations, as exemplified in the »Professionalism in Computing" course described here.

The Opportunity

Teacher preparedness to manage a learning experience in almost any subject is a function of the readily availability of support materials and their abilities to make the best use of those resources. At the same time there is a need to extend the curriculum of all computer-related learning experiences to include a study of computer ethics and social impact, while educational technologies are changing and the teaching/learning environments are reforming rapidly. The most successful teacher is frequently the one that has the best access to background resources and, in the case of ethics and social impact, keeps up-to-date on contemporary issues. Textbooks can provide the core resource for a course, but current topics require an on-line reporter, analyst, and librarian to add new materials as they become available. As new topics arise (such as the repeated US Congressional attempts to develop a Computer Decency Act and the challenges to freedom of expression) they initially receive a great deal of attention in the press and frequently corresponding commentary in newsgroups, but there is rarely a responsible observer who will maintain a on-going summary of the status of the incident and ultimately to produce a closure statement. Even in cases where there is a definitive end to the event, such as the resolution of a dispute through the US Supreme Court, the story of the development of the outcome is an important part of the understanding needed in the study of ethics and social impact. While threads in newsgroups collect the commentaries into a single line, the analysis and evaluation of arguments and situations is necessary to create a learning environment regarding the subject. The fluidity of the topics in ethical standards and social impact in computing creates an opportunity where students can use non-terminated collections of reports to develop their own analytical, evaluative, and presentation skills.

Incorporating resources into meaningful learning experiences and developing active learning scenarios by which students can be involved in their learning opportunities is a process that has not been a part of the training of most computer science professors. The newcomer's major expectation is that given knowledge of the topic, their transformation to teacher from learner is straightforward. Consequently in

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[2] Grant number CDA-9312611.

providing a topical resource today there is a distinct need to go beyond the provision of a knowledge base for information identification and coalescence, so as to provide an appropriate means for the disseminating that information. The system must be able to support the »traditional" lecture class, though distance learning presentations, to self-learning situations.

The Initial Work

Starting in 1994 the EI project commenced its work contemporaneously with the "opening" of the World Wide Web and quickly turned its attention to the use of the Web as the delivery mechanism for digital libraries. Since that time the principal investigators and associated research assistants have applied digital library and Web technology to the presentation of course materials for 75% of the courses in the curriculum of computer science majors at Virginia Tech. The work moved from the use of a passive system to provide an alternative means to paper hand-outs and references to professional publications, to a system with much greater interactivity. Initially this involved the integration of World Wide Web presentations with Internet tools, and expanded to take advantage of the CGI and form capabilities of second generation Web browsers (using PERL and C++), and later to Web Applets implemented in Javascript and Java. Among the tools developed and given limited application were an on-line testing mechanism and an on-line debate system.

Starting in Fall 1994, a digital library in support of a junior-level major's course entitled "Professionalism in Computing" was developed and used as the vehicle for a number of experiments in the use of the Web for course support.[3] This development continued throughout the term of the NSF project, eventually resulting in a collection of over 3000 Web pages. The collection is organized into a number of directories and into two major sections corresponding to topics of general interest and those specific to Virginia Tech. From the beginning, the applicability of the resource to a variety of environments was of paramount importance. The NSF project involved three institutions who expected to benefit from the results, and it was realized that it would not always be the same faculty member at each institution who would have the responsibility of managing the course. Moreover it was recognized that the number of topics to be covered in class could only be a subset of the topics available. A more complete coverage of the topic then required that not only could the course manager select those subjects that are to be used in face-to-face encounters, but those same resources could be used as the crux of (say) take-home assignments or on-line discussions.

From the beginning it was expected that these materials would be used by different faculty at Virginia Tech who would put their own »twist" on the course. No matter how good the textbook, how extensive the resources, how detailed the notes, every faculty member has their own way of presenting materials, adding their own imprimatur and incorporating their own experiences. It was important therefore to modularize the digital library so as to allow each teacher to organize the materials according to their own desires. However, it was realized as the library developed that in moving from a lecture presentation mode of learning to a self-paced, Web-based learning environment, the peculiar influence of the librarian/Webmaster diminishes and the needs of the learner could be fulfilled better with a less structured strategy. This approach also has the advantage that, by eliminating a fixed structure, the contents can be readily updated as new problems arise, new laws are promulgated, precedents are established in court cases, or international diversity is recognized. On the other hand within each module there is structure in the form of a sample class outline, a set of class notes, a bibliography, and a collection of in-class projects.

Each module is currently organized to include seven major files composing the nub of a learning experience:

- *class.html*: the introduction, giving the goals and objectives of the class, links and references to basic readings, and a link to a set of class notes
- *notes.html*: the class notes in a form that can be used for overheads for a lecture[4] or as a set of notes for student self-paced learning.
- *bibliography.html*: a bibliography relevant to the topic especially emphasizing links to on-line resources so as to provide additional reading materials in support of the class. As far as possible, the majority of the on-line references in this file are contained in the same directory as the bibliography, though copyright restrictions have limited the accessibility of some material.

[3] At http://ei.cs.vt.edu/~cs3604

[4] The notes exist in several different formats; some are in the form of HTML pages requiring no further application than the standard browser, others are in PDF and thus requiring the auxiliary use of an Acrobat reader. This was used in the prior project to evaluate the efficacy of each methodology. The former has the advantage of not requiring the second application, but is limited in formatting (pretty-printing) by HTML capabilities. However it is easy to modify the notes and is amenable to on-line editing through special agents. The PDF style allows the conversion of materials gathered from other sources to be presented is a very attractive format. However the ability to modify the materials is much more complicated.

- *projects.html*: a collection of class projects. Some require groups of participants to review the pertinent materials and then prepare a class presentation on some particular aspect of the topic, while others are active learning projects, including those from the USF workshop (see below).
- *scenarios.html*: a collection of synthetic and real-life scenarios for use in in-class discussions or for use in the debate system.
- *examinations.html*: examination questions. This section is being modified into an on-line self-testing area, with a view of using it as a means of providing self-testing for learners, and eventually as a means of managing learning progression through modular testing.
- *current.html*: the current topics area is maintained as an attempt to keep up-to-date in the area of concern. This area provides an opportunity for students to be involved in the maintenance of the site by providing links and reports. In fact, our management of the course provides opportunities in each assignment for the expansion of the site through student contributions.

Active Learning

Typically active-learning approaches involve mutual learning projects. Karl A. Smith said of the more traditional style of teaching: "When students attend a college class, they typically expect to sit passively and listen to a professor 'profess'; they expect to be evaluated based on their individual course work—exams, papers, and quizzes—and they bring with them a set of norms for interacting with their classmates. Based on their past experiences with school, many students believe that they are in competition with their classmates for scarce resources—good grades"[5] Active learning reverses these roles and attitudes. The responsibility for learning is shared by both the learner and the learning manager.

In support of this distribution, the University of New Hampshire Center for Academic Resources advises students: "Active learning means taking responsibility for your learning and developing habits of mind and study strategies that will be
the means for accomplishing your academic goals. Responsibility is the toughest part: know that college expects that you will take charge of your learning -- that you will go to class, do assignments, and embrace confusion and "wrong answers" as opportunities to try again...If it hasn't occurred to you yet, know that from here on in you are THE responsible agent for your learning and life."[6]

To the faculty member the High/Scope Educational Research Foundation suggests that active learning is a methodology that:

"1. Exercises and challenges the capacities of the learner that are emerging at a given developmental level.
2. Encourages and helps the learner to develop a unique pattern of interests, talents, and goals.
3. Presents learning experiences when learners are best able to master, generalize, and retain what they learn and can relate it to previous experiences and future expectations."[7]

The challenge then is to overcome the propensity to easily adapt the web to be a simpler purveyor of reading materials and to develop an interactive learning environment.

Steps toward Discovery

Each active-learning project is intended to focus on five steps:

1. The discovery and realization of the problem;
2. The identification of the tools and resources to solve the problem;
3. The examination of alternative strategies for solution;
4. The implementation of a chosen solution; and
5. Reflection on the solution, assessment of the outcome, and reworking of the process of solution identification.

These steps can readily be divided into pre-, in-, and post-class activities, or assigned to individual explorations, group collaborative efforts, or whole-class undertakings. There is no restriction on whether the work is done synchronously (in-class for example) or asynchronously (pre- and post-class, or as a take-home assignment). It has been our common approach to assign steps 1 and 2 (discovery and identification) as a pre-class, individual activity. The identification of tools and resources is perhaps best done outside the classroom, though in a laboratory setting it is possible to undertake »scavenger-hunts" on the Web to locate resources and solutions. Step 3, looking at the alternatives, lends itself easily to a (possibly in-class or pre-class) group activity. Implementation and reflection are excellent topics for an in-class discussion, though the reflection element can be extended into a post-class assignment for individual thought and cogitation.

One of the simplest tools that we have found to be extremely useful is a on-line count-down clock! Within a class when students are working on individual or group projects it is essential that they have some guide to the time that is left for their work. To manage the in-class activities to conform to the

[5] Karl A. Smith, quoted at http://www.unca.edu/et/br120996.htm
[6] http://www.cfar.unh.edu/activelearning.html
[7] http://www.ecdgroup.com/guestdoc/hspc.html

allotted requires careful timing and adherence to a schedule. Keeping activities on time and restricting activities to a set time span can be used as a management tool to get to the point and to ensure that decisions are made. Later reflection will confirm (in our experience) that given the resources available an appropriate decision was made even under time pressures. Obviously it is the responsibility of the manager to ensure that there is sufficient time. The movement of portions of a project to pre- and post-class activities effectively extends the in-class project time allowance. Written in Javascript it can be easily ported to any course Web-site[8]:

There are two major elements of the course where it is essential that participants develop »community standards". The first of these is associated with peer-evaluations that take place as part of the oral-communications segment of the course. Through a time-restricted decision-making exercise, the class decides on the criteria for evaluation of their fellow students in individual presentations. Breaking down the categories for evaluation into content, oral-presentation, and supporting-graphics, the class (often in excess of 60) creates a set of mutually agreed metrics for evaluation.[9] The technique of decision-making[10] is simply that used in many large group decision-making projects, starting with having individuals choose three criteria for each category, then working in groups to choose four, through sub-committees of group leaders who select five, and finally representatives of the subcommittees who select the final six criteria. For most students this is the first time that they have ever been placed in the position of having to make large group decisions and are surprised that it can be accomplished in a short time. The same technique is used a second time in the development of community standards for the conduct of the on-line debates. As a part of the class period on Netiquette (with a pre-class activity planned to recognize the problem and the resources for solution) the class decides on the rules of conduct in the forthcoming on-line debates. A similar preparatory exercise is the Behavioral Analysis activity that is used to organize students into groups. In this case students have a pre-class activity to determine their behavioral characteristics through the use of a forty element questionnaire. Classified into one of four categories (controller, analyzer, promoter, or supporter), clusters of like temperament explore their likes and dislikes in preparation for a presentation that will eventually lead into a broader discussion of interpersonal relationships in group settings.[11] From the results of the pre-class analysis the instructor attempts to establish groups that will work together effectively for the remainder of the course.

The pre-class discovery is also a lead-in to the class on »Rules We Live By" [12] where students explore the driving forces in their life and ballot on the »values" that influence their decision making.[13] The top five choices for the past several semesters are shown in table 1.

Once developed prior to class, this survey makes an excellent tool for an in-class discussion of the differences between laws and ethics, and between codes of conduct and community values. This mechanism can also be used as a course or module pre-test for assessment purposes in other topics.

Ask almost any student on the first day of a term what he/she considers to be the primary concern of a course in computer ethics and the most likely response will be »hacking". This topic is a prime candidate for an active-learning exercise. Using two readily accessible articles on hacking to be read in advance of

[8] http://ei.cs.vt.edu/Clock/Countdown.html

[9] Generally students are peer-evaluated for performance in their first presentation but the results do not affect their grade, it is simply for direction. Thereafter, the group evaluation determines their score. Other faculty have graded all oral presentations.

[10] http://ei.cs.vt.edu/cgi-bin/cs3604/debate.decision.pl

[11] http://ei.cs.vt.edu/~~cs3604/support/Groups/class.html

[12] http://ei.cs.vt.edu/~cs3604/support/IntroClass/class.html

[13] http://ei.cs.vt.edu/cgi-bin/cs3604/Survey.Values.pl

the class, the class activity centers around exploring the answers to twelve questions that the students have explored by their groups for ten minutes:[14] See Table 2.

A succeeding class can then concentrate on security as a tool for systems administrators and complete the strategies, implementation, and reflection elements of the activity.

Spring 1997	Fall 1997	Fall 1998	Spring 1999
Family	Family	Honesty	Integrity
Honesty	Happiness	Family	Family
Religion	Religion	Religion	Responsibiliti
Education	Friendship	Trust	es
Friendship	Compassion	Friendship	Friendship
			Honesty

Table 1: Driving Values

Read the articles entitled "Reformed Crackers Reveal Their Secrets To Paying Audiences of Former Victims", *New Dimensions International*, 1997 and NOW HIRING: HACKERS (TATTOOS WELCOME), Special to the *Chicago Tribune*, April 12, 1998. Then answer the following questions:

1. What is the difference between a hacker and a cracker?
2. What is a sniffer?
3. Can a consultant who has not been a "true hacker" actually provide any advice to potential targets for hackers?
4. Is there a difference between benign and malicious hackers?
5. In Virginia Law, is there a difference between benign and malicious hackers?
6. Is it appropriate for "criminals" to benefit from their previous misdeeds?
7. Is hacking becoming an industry?
8. Should hacking tools, such as password crackers, be controlled by the government? If not, why not?
9. Should a university computer science such as ours have a course on hacking?
10. Is it not better to have enough knowledge about hacking to protect your company against it? How much knowledge is sufficient?

Table 2.

Ask the participants in the class to spend a minute defining ATTITUDE and ACTION in the context of LOVE and HATE. Then review their answers looking for key words such as thoughts, feelings, behavior, disposition, manner, feeling, temperament, spirit, sensibility, perspective, viewpoint, point of view, response, deed, act, conflict , encounter, etc. Create a listing of keywords for each on the board.

Table 3.

1. Is love an attitude or an action?
2. Is hate an attitude or an action?
3. When does feeling of love lead to action? What causes this change?
4. When does feeling of hate lead to action? What causes this change?
5. Does attitude eventually develop into action?
6. Can attitude be acceptable and action not?
7. Is there a boundary between acceptable attitude and unacceptable action?
8. Is the statement of hate without action acceptable?
9. What is the difference between toleration and acceptance?
10. Is the statement of hate an action?
11. How do "community standards" control hate?
12. Should "community standards" control hate?
13. How does this apply to Freedom of Speech?
14. How does this apply to the Internet?
15. Is posting hate material on the WWW an expression of attitude or an action?

Table 4.

Freedom of Speech is a topic that has many scenarios that can lead to active-learning projects. The sample project is based on the George Orwell book »1984" and the US Constitution, supplemented by

[14] http://ei.cs.vt.edu/~cs3604/lib/Hacking/projects.html

visits by the participants to »cyberhate" sites intending to explore the gray area between offensive and tolerated speech.[15] Using pairs of key words groups are led through comparisons between narrowing extremes of concepts - love and hate, attitude versus action, and finally the differences between acceptance and tolerance. Typical of the activities is the suggestions in Table 3, followed by the following questions that will provoke further discussion shown in Table 4.

Using examples from the Hate Directory [16] it is possible to study the differences between these terms and how they are applicable to the question of freedom of speech on the Web. Discussion can evolve around the statement:

ideas have consequences

and the question »at what point is it necessary or appropriate in a democratic society (the antithesis of Oceana in '1984') to take action to limit free speech?" The recent Oregon court case that awarded damages to a group of abortion doctors against a Web-site that named them and appeared to promote hostile actions against them is a noteworthy case for discussion in this context.[17]

As noted above, the primary impetus for the inclusion of active learning activities within the site came from the NSF sponsored workshop at the University of South Florida.[18] A major portion of that workshop was spent in the development of projects that could be used in Computer Science courses. The work on developing activities has continued and in particular has been incorporated into the lesson plans for most topics. The *projects.html* page of most directories now contains back links to the USF compendium as well as additional local developments.

In general, experience shows that it is essential that students have a pre-class activity prior to a class that will involve active learning so that they are prepared to participate. The task of attempting to not only provide the fundamentals of the subject and motivate participants to be involved in an active-learning experience, followed by a summary and assessment, simply does not fit into a single class period. On the other hand, the pre-class activity imbues a commitment on the part of the students to learn more about the topic and to be more involved in the activity.

Collaborative Development

The digital library has been expanded by collaboration with faculty at several other institutions. From Spring 1995 a collaborative arrangement with MIT Computer Science Laboratory has allowed the two institutions to share resources, some of it in the form of links from the general interest section to pages stored at MIT and the mirroring of some pages so as to ensure the preservation of the materials in one place. An agreement with Florida Atlantic University provides a directory on "Netiquette" to both institutions. The class notes on the Y2K problem were provided by the Naval Postgraduate School in Monterey, California. As part of the 1998 NSF-funded summer workshop at the University of South Florida under the direction of Kevin Bowyer, twenty colleagues were recruited as collaborators in the development of active learning scenarios in support of the individual topics. The primary repository of this collection is located at USF[19]; the individual scenarios are linked from the projects.html pages in the Virginia Tech library, augmented by bibliographies of readings and current events.

Among the goals for the inclusion of two other institutions in the use of the materials was twofold: (1) to evaluate the ability of other faculty and students to assimilate the course library, and (2) to expand the discussion population. On the latter point, it was recognized that the student population at Virginia Tech is primarily white and conservative; Norfolk State University is a traditional black institution in Tidewater Virginia serving an urban community of students with a very different social background from those at Virginia Tech; Heritage College is a unique liberal arts college located where no other four-year college exists. Fifty percent of the college's undergraduate students are either Native American or Hispanic Americans. Eighty-five percent are the first persons in their families to attend college and sixty percent live below the poverty level. Many Heritage students are farm workers and/or single mothers; women make up 70 percent of the undergraduate student body.

Each institution used the course library in a different manner. While Virginia Tech had moved to a Web-based course style using classrooms with Computer Assisted Teaching Systems (CATs), Norfolk State and Heritage used a seminar format in which students studied topics using the Web-based materials (in an order of their own choosing) and then met once a week with a faculty member[20] to discuss their findings. An attempt was made to involve the three groups of (roughly 100) students in joint debates, with the hope that these three disparate populations would come down on different sides of certain issues. Three debate topics were chosen for these joint debates dealing with current issues in computing — a case of the appropriateness of minority representation on the Board of Directors of a major computer

[15] http://ei.cs.vt.edu/~cs3604/lib/Freedom.of.Speech/projects.html
[16] http://www.bcpl.net/~rfrankli/hatedir.htm
[17] http://www.lawnewsnetwork.com/stories/feb/e020899h.html
[18] http://marathon.csee.usf.edu/~kwb/nsf-ufe/index.html
[19] http://marathon.csee.usf.edu/~kwb/nsf-ufe/exercises.overview.html
[20] It should be noted that at both institutions other faculty participated occasionally for the pleasure of it!

corporation (based on actual correspondence between the company's President and a stockholder, with permission of both parties), cryptography and the clipper chip, and a charge of plagiarism against an unnamed student who copied the format and background of another student in preparing a home page. While the debates were well subscribed, the differences in student backgrounds did not emerge as vividly as expected. This may be partially the result of a more restricted access to terminals at Norfolk State and Heritage than is common at Virginia Tech. It is hoped that through this project, this experiment can be repeated with improved access facilities.

In evaluating their involvement Richard Barnhart of Heritage College reported:

> »It was interesting over the course of a couple of weeks to see the class's attitudes changing over the plagiarism/copyright/'look and feel' question. Their initial reaction was 'get a life'. They came to understand that there are many such issues that they will face, especially since most of them will be 'the' computer person for some company or department, and that people will have questions and issues come up constantly. These students very frequently will have network privileges into all parts of the corporation; many of them had never thought of this in the context of ethics."

Unsolicited responses were received from other institutions who had used the materials but had not »registered" with us as participants in the experiment. Typical of these (and most interesting) is the comment from the United Arab Emirates:

> »Just a quick note to say that I really have enjoyed visiting your site, and in particular reading the student responses to your ethical dilemmas.
>
> I am trying to build a similar (if lower level) course on computer ethics for some Higher Diploma Information Administration students in Abu Dhabi, United Arab Emirates and think that your idea of creating an on-line discussion group is an excellent way of making the students come to grips with ethical dilemmas in a way which extends far beyond a listing of the 10 commandments...
>
> This should be interesting as my students are all women, have very strict Muslim social codes and have in many cases have led very sheltered lives."

Collaborative Learning and Managed Discussion

The development of a digital library to support teaching and learning in computer ethics and the social impact of a computer through the earlier NSF grant has now reached the point where it is moving from an primarily passive system to a much more interactive arrangement. Initially interaction was provided through the development of an on-line debate system[21] modeled after the CERN product WIT.[22] Prior to the development of Web-based resources, this course had used an »Oxford Union" style debating system to discuss ethical scenarios and current issues. With restricted class time, this provided the opportunity for only a limited number of students to participate, and much of the discussion relied on spur of the moment reactions in order to contribute to the argument. A survey of student participation revealed that the debates were dominated by extroverted white males, while more thoughtful women and students whose first language was not English were at a considerable disadvantage. By putting the debate on-line and allowing several days for asynchronous participation, it was immediately apparent that there was a wider diversity of opinion and more reasoned contributions. The latter benefit was partially instigated by the requirement that the price of participation was the inclusion in each contribution of either a (preferably Web-based) reference or a conjunction of the argument with an ethical principle. Moreover »me-too" statements were outlawed and negative contentions were required to be accompanied by a rationale. Initially the debate system was organized as four tree structured threads, the initial node of each branch being one of four primary position statements developed by the student-led debate management team, followed by the point and counterpoint statements from the class participants. As other courses began to use the system as a collaborative development methodology, it was modified to permit a number of different arrangements basically varying from the strict discipline of the debates to the »free-for-all" of a chat room. The system has also been used by other courses as a collaborative development tool, and in other situations as a decision-making vehicle.

Changing Pedagogy

With our new infrastructure becoming available, use has been made of laboratories and networking to better accommodate student preferences and to add interactivity to the learning experience. Certain courses shifted from lecture-only, to having occasional sessions in a laboratory, or half of the classes in a lab, or (in select cases) all sessions in a lab. Even though Virginia Tech Computer Science majors have bought workstations as entering freshmen since 1985 and use them extensively in both standalone and networked modes, students find the laboratories to be of great value, and benefit from the interactive learning that takes place in both »open" and »closed" laboratories. Results from a survey of students in the spring 1996 course on multimedia indicate a strong consensus that more time in laboratory is preferable, and less time is desired for lectures. Similar comments came from many students in the

[21] At http://ei.cs.vt.edu:8000/

[22] Laughton, 1996, and Luotonen, 1994.

freshman Operating System Tools. A survey administered to both the classes, as well as focus groups conducted for those courses, confirmed the earlier informal observation that students vary widely in their beliefs regarding where they learn best (e.g., in lecture, laboratory, or at home). It was also found that though students differ in their rankings of the value of online resources and services (e.g., old quizes, email, LISTSERV®, newsgroups), most wanted information with clear practical use (e.g., lecture notes, assignments) plus some combination of passive and active communication mechanisms (e.g., WWW pages, email).[23]

The retention of student contributions in the library is an integral part of this project. This will help in not only expanding the content but also creates a model for others to emulate in their own research, study and writing.[24]

Conclusions

Web-based learning is a growing phenomenon that has yet to reach its full capability. Much has been made of the Web simply as a passive searchable resource, and our experience already records that many learning opportunities have been satisfied through this mechanism, but data »mining" is truly only a precursor of data analysis and refinement. Substantive learning can only be achieved through the management of data acquisition, and the collaborative development and reinforcement of concepts. The general tenets of Computer Aided Instruction (CAI) can now be implemented in a Web-based learning environment built and maintained on the basis of a digital library.This paper is a progress report on the road from an almost obsolete technology of 1993 to the learning environment of the 21st century. What we accomplish here will be a model for other university courses, and eventually for classes at other levels. The study of the social impact of the computer and computer ethics should not be limited to post-secondary computer education, but should be available to all users of computers. Through this system perhaps we can find ways to incorporate elements of computer ethics into many courses.

In conclusion, besides the course discussed herein, we have worked on a wide range of objectives around the theme of improving learning by increasing interactivity and by applying digital library concepts, content and systems. As a result, a new infrastructure has emerged, our pedagogy has been transformed, utilization of the courseware we developed has grown rapidly both locally and remotely, and many tools have been constructed. Students learn new topics, often in new ways, and we have continued to progress in developing digital library content, systems, and interfaces.

Related papers can be found at:

http://fox.cs.vt.edu/FIE96.pdf (Project Overview, 1996 Frontiers in Education Conference)

http://ei.cs.vt.edu/~cs3604/CWRU.html (Professionalism in Computing: A Web-based Learning System, prepared for the *International Conference on Ethics in Engineering and Computer Science*, Ethics Center for Engineering and Science, March 1999.)

http://ei.cs.vt.edu/~cs3604/FIE99.html (Incorporating Active Learning into a Web-based Ethics Course, prepared for the *1999 Frontiers in Education Conference*, San Juan, Puerto Rico, 10-13 November 1999.)

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[23] http://fox.cs.vt.edu/FIE96.pdf

[24] As an ongoing project, student essays and reports on aspects of computer history have been added to the supporting notes of the PBS video series »The Machine That Changed The World" to provide background information for »further reading" by the viewers.

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